Attorney Docket No.: 3008-1028

PATENT

IN THE U.S. PATENT AND TRADEMARK OFFICE

Applicant: Richard Warrington GEORGE Conf. No.: Unknown

Appl. No.: 10/615,235 Group: Unknown

Filed: July 9, 2003

For: ISOLATING POWER SUPPLY

L E T T E R

Assistant Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Date: July 25, 2003

Sir:

Under the provisions of 35 U.S.C. § 119 and 37 C.F.R. § 1.55(a), the applicant(s) hereby claim(s) the right of priority based on the following application(s):

Country	Application No.	Filed
UNITED KINGDOM	0215814.5	July 9, 2002
UNITED KINGDOM	0303012.9	February 11, 2003

A certified copy of the above-noted application(s) is(are) attached hereto.

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Respectfully submitted,

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Attachment

(Rev. 04/19/2000)

The Patent Office
Concept House
Cardiff Road
Newport
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NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

I also certify that the attached copy of the request for grant of a Patent (Form 1/77) bears an amendment, effected by this office, following a request by the applicant and agreed to by the Comptroller-General.

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P01/7700 0.00-0215814.5

THE PATENT OFFICE
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Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

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Cardiff Road
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1. Your reference

   MRH.PO4697GB

   09 JUL 2002

2. Patent application number
   (The Patent Office will fill in this part)

   0215814.5

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

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   Patents ADP number *(if you know it)*

   If the applicant is a corporate body, give the country/state of its incorporation

   6935365002

4. Title of the invention

   ISOLATING POWER SUPPLY

5. Name of your agent *(if you have one)*

   Marks and Clerk.

   ~~A R Davies & Co~~
   27 Imperial Square
   Cheltenham
   GL50 1RQ

   "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

   570001

   Patents ADP number *(if you know it)*

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

   a) any applicant named in part 3 is not an inventor, or
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   See note (d))

   No

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Description	9
Claim(s)	3
Abstract	1
Drawing(s)	3 +3

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Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature A R Davies & Co Date 8th July 2002

12. Name and daytime telephone number of person to contact in the United Kingdom

Mr M R Higgins
01242 524520

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ISOLATING POWER SUPPLY

This invention relates to an isolating power supply for electrical equipment.

Over recent years, as the resolution and accuracy of high performance audio and sound equipment has improved, it has become clear that the quality and accuracy of sound reproduction can be dependant on, and adversely effected by, the quality of the incoming power supply to the equipment.

This degradation is due to several factors including unwanted noise superimposed on the power supply by loads with poor power factor, connection to loads which contaminate the supply with radio frequency interference (R.F.I.), and the pickup of R.F.I. and other interference by cabling feeding the equipment.

To counter this problem many manufacturers now offer costly mains conditioning units, mains filters and specialist low inductance noise cancelling cables for connection between the incoming supply and the equipment.

However, while reducing mains pollution these products can have an adverse effect on sound as a result of increasing the supply impedance or increasing capacitive or inductive loading across or in series with the electrical equipment, hereinafter referred to as the 'load'.

The present invention seeks to overcome this problem.

According to the present invention, there is provided an isolating power supply for electrical equipment, comprising a transformer having an input for a mains alternating current (AC) power supply, a rectifier by which the output of the transformer can be rectified, a primary energy storage device for electrically smoothing the output of the rectifier, a switching device which is electrically connected to the output of the primary energy storage device and which can be switched between a conducting state and a non-conducting state, and a secondary energy storage device which is electrically connected to the switching device, so that in use when the switching device is in a non-conducting state the primary energy storage device stores the output from the rectifier and the secondary energy storage device is electrically isolated from the primary energy storage device and supplies an electrical output to associated electrical equipment, and, when the switching device is in a conducting state, the primary and secondary energy storage devices are electrically connected and the secondary energy storage device stores the output from the primary energy storage device.

Preferable and/or optional features of the present invention are set forth in claims 2 to 13, inclusive.

The present invention will now be described, by way of example, with reference to the accompanying drawings, wherein :

Figure 1 is a circuit diagram of a conventional prior art power supply for electrical equipment;

Figure 2 is a circuit diagram of a one embodiment of an isolating power supply, in accordance with the present invention;

Figure 3 shows graphs traced on a dual-channel oscilloscope when connected to the isolating power supply;

Figure 4 shows further graphs traced on the dual-channel oscilloscope when connected to the isolating power supply;

Figure 5 is a detailed circuit diagram of an isolating power supply developed to give a +/- 12V DC supply.

Referring firstly to Figure 1 of the drawings, there is shown a circuit diagram of a conventional direct-current (DC) power supply, such as is used in most compact-disk (CD) players, Pre-Amplifiers, and Power Amps.

The incoming mains voltage 10 is reduced to a suitable voltage via a conventional transformer 12, and the output from this is fed to a, typically bridge, rectifier 14. The output of the bridge rectifier 14 is smoothed using large electrolytic capacitors 16 (only one shown).

In use, as the alternating-current (AC) voltage output from the transformer 12 rises sinusoidally above the output rail voltage of the supply 10, the diodes 18 in the bridge rectifier 14 conduct to charge the smoothing or reservoir capacitors 16.

The transformer output voltage then drops below the rail voltage, and the diodes 18 in the bridge rectifier 14 stop conducting.

At this point the load is fed exclusively by the smoothing capacitors 16, the voltage of which drops as power is drawn prior to the next recharging cycle. As the AC voltage output from the transformer 12 rises again above the output rail voltage of the supply, the diodes 18 in the bridge rectifier 14 conduct to recharge the smoothing capacitors 16.

This discharge/recharge cycle produces voltage variation or ripple on the supply rails.

To overcome this, an integrated circuit or monolithic-type active voltage regulator (not shown) is typically used at the output to reduce ripple and noise whilst reducing source impedance. For best results two regulators will be used to give two stage regulation, for example, from a rail voltage of 27V regulated down to 18V then to 12V. This gives up to 80db rejection of ripple and noise.

In addition to this, separate power supplies may be used to feed the individual channels of, say, a pre-amplifier to improve isolation and reduce crosstalk between left and right hand channels.

This technique is also commonly used in equipment using both digital and analogue circuits, for example, CD players, to provide isolation between digital and

analogue circuits for improved performance.

Referring now to Figure 2, there is shown a circuit diagram of a first embodiment of an isolating power supply, in accordance with the present invention.

Incoming mains AC power 20 is stepped down in voltage using a transformer 22. The output of the transformer 22 is then rectified using a, typically bridge, rectifier 24 and smoothed using one or more conventional electrolytic-type primary capacitors 26 (only one shown), as per the normal type supply.

The output of the or each primary capacitor 26 is connected to a power metal oxide semiconductor field-effect transistor (MOSFET) 28, or other semiconductor, which can act as a fast switch device 30. This power MOSFET switching device 30 is controlled by a control signal 32 exhibiting a square waveform which is 180° out of phase with the mains AC signal. The mark space ratio of the square wave control signal is set to give, in use, the required switching pattern. The MOSFET switching device 30 is coupled to this control signal 32 using an opto-isolator (not shown) to give total isolation from the incoming mains supply 20.

The output from the MOSFET switching device 30 is connected to one or more secondary electrolytic capacitors 34, which is/are connected across the rails feeding the load.

In use, the MOSFET switching device 30 is turned OFF while the or each

primary capacitor 26 is being recharged from the incoming mains supply 20 so that no conduction occurs between the primary and secondary capacitors 26 and 34. Once recharging is complete, and the bridge rectifier 24 has stopped conducting power from the incoming supply 20, the square waveform of the control signal 32 goes HIGH, turning the MOSFET switching device 30 ON, and thus allowing the or each primary capacitor 26 to recharge the or each secondary capacitor 34.

When this is complete, the control signal 32 goes LOW and the MOSFET switching device 30 is turned OFF again prior to recharging of the or each primary capacitor 26 from the incoming mains supply 20.

Looking in more detail at the operation of the circuit, Figure 3 shows the print out from a dual channel oscilloscope.

This shows a sinusoidal trace 1 of the incoming supply 20 to the bridge rectifier 24, and trace 2 shows the square wave signal, used to control the MOSFET switching device 30 on the positive power rail, which is 180 degrees out of phase with the incoming mains AC supply 20.

When the incoming AC supply 20 is HIGH, and charging of the or each primary capacitor 26 occurs, the MOSFET switching device 30 is LOW and the secondary capacitor 34 is completely electrically isolated from the primary capacitor 26. When the AC supply 20 goes LOW and charging of the or each primary capacitor 26 no longer occurs, the control signal 32 goes HIGH causing the MOSFET switching

device 30 to go HIGH, so that conduction and thus recharging of the or each secondary capacitor 34 from the or each primary capacitor 26 occurs.

Figure 4 is again a print out from a dual channel oscilloscope. Trace B shows voltage variation on the or each primary capacitor 26, whilst trace C shows the voltage variation on the or each secondary capacitor 34.

At point D, the bridge rectifier 24 starts conducting and the voltage of the or each primary capacitor 26 increases. At point E, the bridge rectifier 24 stops conducting and the voltage of the or each primary capacitor 26 falls slightly to point F. At point G the MOSFET switching device 30 starts to conduct, causing the voltage of the or each primary capacitor 26 to fall whilst the voltage of the or each secondary capacitor 34 rises to point H. The primary and secondary capacitors 26 and 34 then work in parallel to feed the load with a slow fall in voltage until point I just before the or each primary capacitor 26 starts to recharge. At this point, the MOSFET switching device 30 turns OFF prior to the cycle repeating.

Note, in Figure 4, low value capacitors have been used to magnify and show clearly the switching sequence.

The same principles can be used to make a dual rail supply. In this case, a MOSFET switching device is used on both supply rails and controlled by square wave switching 180^0 out of phase with the relevant positive or negative part of the AC supply. Figure 5 shows a detailed circuit diagram of an isolating power supply

developed to give a +/- 12V DC supply.

It should be understood that, although the semiconductor switching device has been described as only operating between an ON and an OFF state, its conduction could vary sinusoidally, or in any other suitable manner, over a range between a conducting state and a non-conducting state, as long as the variation is out of phase with the incoming AC mains supply, so that conduction between the primary capacitor and the secondary capacitor does not occur while the primary capacitor is being recharged.

As well as providing isolation from the mains power supply, the circuit design can also be used to provide total isolation between circuits. This can be achieved using two supplies fed from a single transformer.

It is possible to use other energy storage devices to store the energy in place of electrolytic capacitors. For example, inductors could be utilised.

In addition to a power MOSFET switching device, or other semiconductor switching device, any other suitable switching device which can provide total isolation of the secondary energy storage device from the incoming mains power supply could be used.

It is thus possible to provide total isolation from a contaminated incoming mains supply, and to provide isolation between circuits, by the inclusion of a

switching system and one or more additional energy storage devices. Sound quality and reproduction can thus be maintained without the necessary requirement of costly mains conditioning units, filters and specialist noise cancelling cables and the disadvantages associated therewith.

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The embodiments described above are given by way of examples only, and various modifications will be apparent to persons skilled in the art without departing from the scope of the invention as defined by the appended claims.

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CLAIMS

1. An isolating power supply for electrical equipment, comprising a transformer having an input for a mains alternating current (AC) power supply, a rectifier by which the output of the transformer can be rectified, a primary energy storage device for electrically smoothing the output of the rectifier, a switching device which is electrically connected to the output of the primary energy storage device and which can be switched between a conducting state and a non-conducting state, and a secondary energy storage device which is electrically connected to the switching device, so that in use when the switching device is in a non-conducting state the primary energy storage device stores the output from the rectifier and the secondary energy storage device is electrically isolated from the primary energy storage device and supplies an electrical output to associated electrical equipment, and, when the switching device is in a conducting state, the primary and secondary energy storage devices are electrically connected and the secondary energy storage device stores the output from the primary energy storage device.

2. An isolating power supply as claimed in claim 1, wherein the switching device is a semiconductor switching device.

3. An isolating power supply as claimed in claim 2, wherein the semiconductor switching device is electrically connected to a control signal via an opto-isolator.

4. An isolating power supply as claimed in claim 4, wherein the control signal is

180^0 out of phase with the mains AC power supply.

5. An isolating power supply as claimed in claim 3 or claim 4, wherein the control signal has a square waveform.

6. An isolating power supply as claimed in any one of claims 2 to 5, wherein the switching device is a metal oxide semiconductor field-effect transistor (MOSFET).

7. An isolating power supply as claimed in any one of the preceding claims, wherein the primary energy storage device is a capacitor.

8. An isolating power supply as claimed in any one of claims 1 to 6, wherein the primary energy storage device is an inductor.

9. An isolating power supply as claimed in any one of the preceding claims, wherein the secondary energy storage device is a capacitor.

10. An isolating power supply as claimed in any one of claims 1 to 8, wherein the secondary energy storage device is an inductor.

11. An isolating power supply as claimed in any one of the preceding claims, wherein a plurality of primary energy storage devices are provided.

12. An isolating power supply as claimed in any one of the preceding claims,

wherein a plurality of secondary energy storage devices are provided.

13. An isolating power supply as claimed in any one of the preceding claims, wherein the rectifier is a bridge rectifier.

14. An isolating power supply substantially as hereinbefore described with reference to Figures 1 to 4, or Figure 5 of the accompanying drawings.

ABSTRACT

ISOLATING POWER SUPPLY

An isolating power supply for electrical equipment comprises a transformer 22 having an input for a mains alternating current (AC) power supply 20, a rectifier 24 by which the output of the transformer 20 can be rectified, and a primary energy storage device 26 for electrically smoothing the output of the rectifier 24. A switching device 30 is provided which is electrically connected to the output of the primary energy storage device 26 and which can be switched between a conducting state and a non-conducting state, and a secondary energy storage device 34 is also provided which is electrically connected to the switching device 30. In use, when the switching device 30 is in a non-conducting state, the primary energy storage device 26 stores the output from the rectifier 24 and the secondary energy storage device 34 is electrically isolated from the primary energy storage device 26 and supplies an electrical output to associated electrical equipment. When the switching device 30 is a conducting state, the primary and secondary energy storage devices 26,34 are electrically connected and the secondary energy storage device 34 stores the output from the primary energy storage device 26. Preferably, the switching device 30 is a power MOSFET switching device.

(Refer to Figure 2)

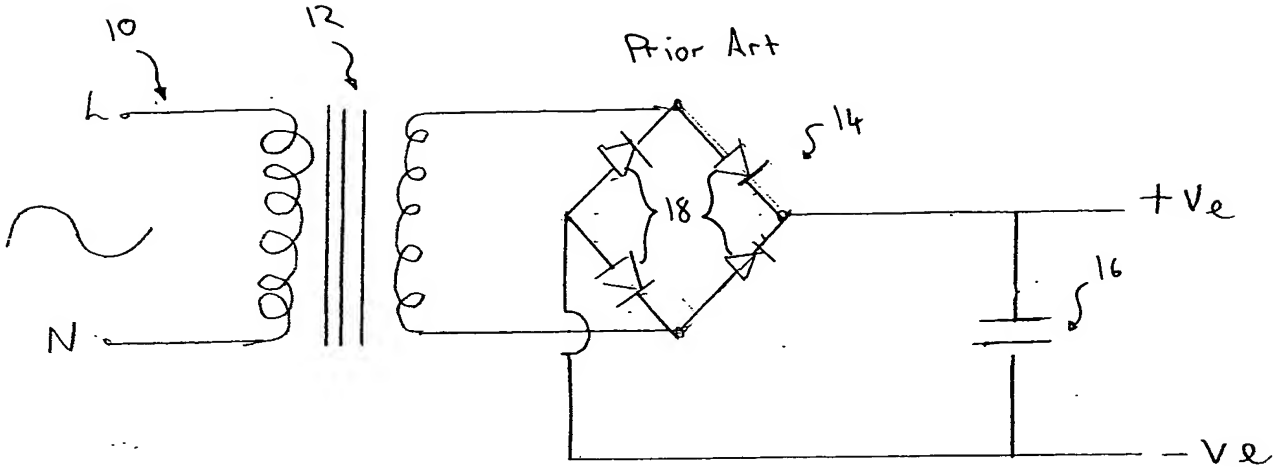


FIGURE 1

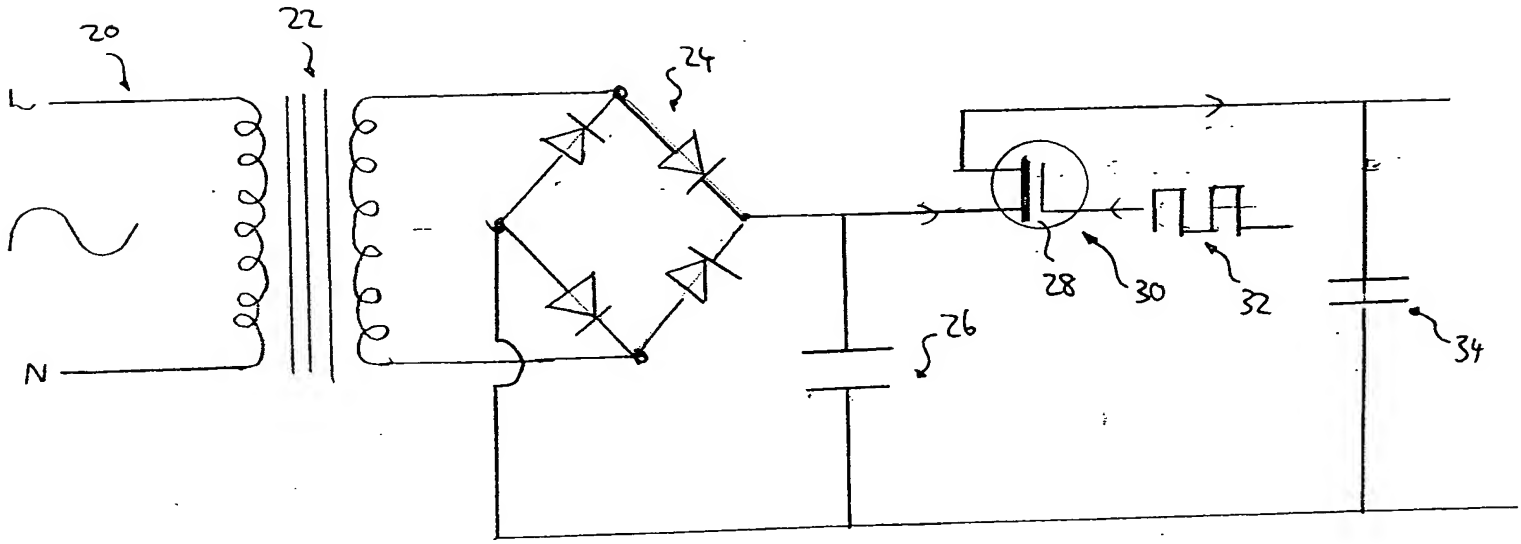


FIGURE 2

Figure 3

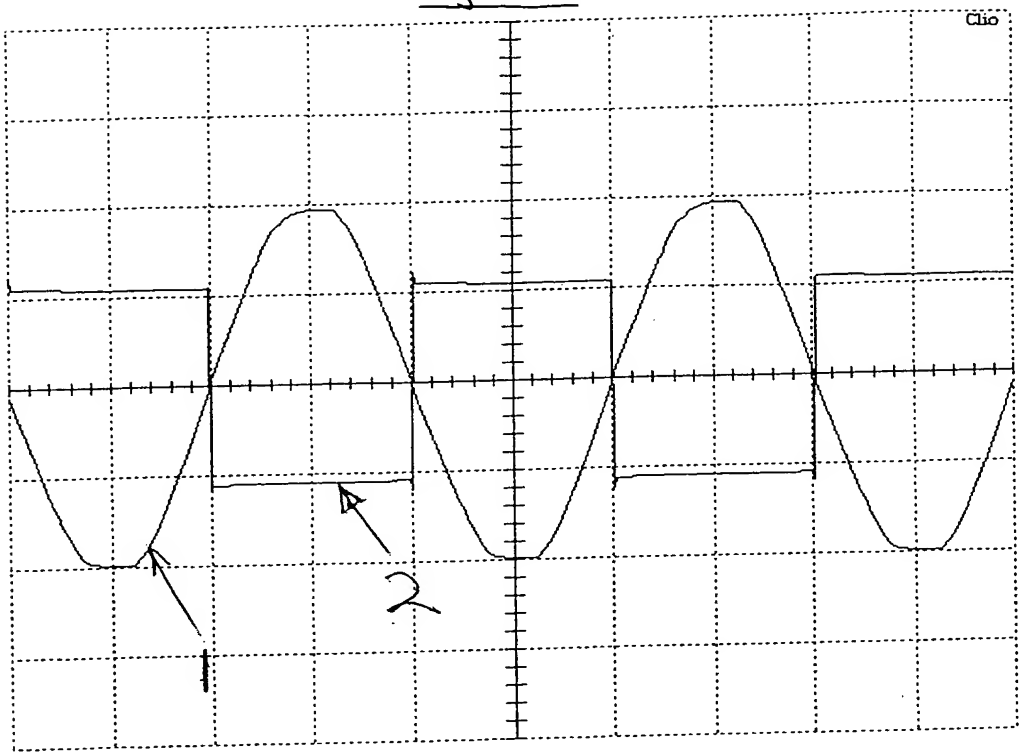


Figure 4

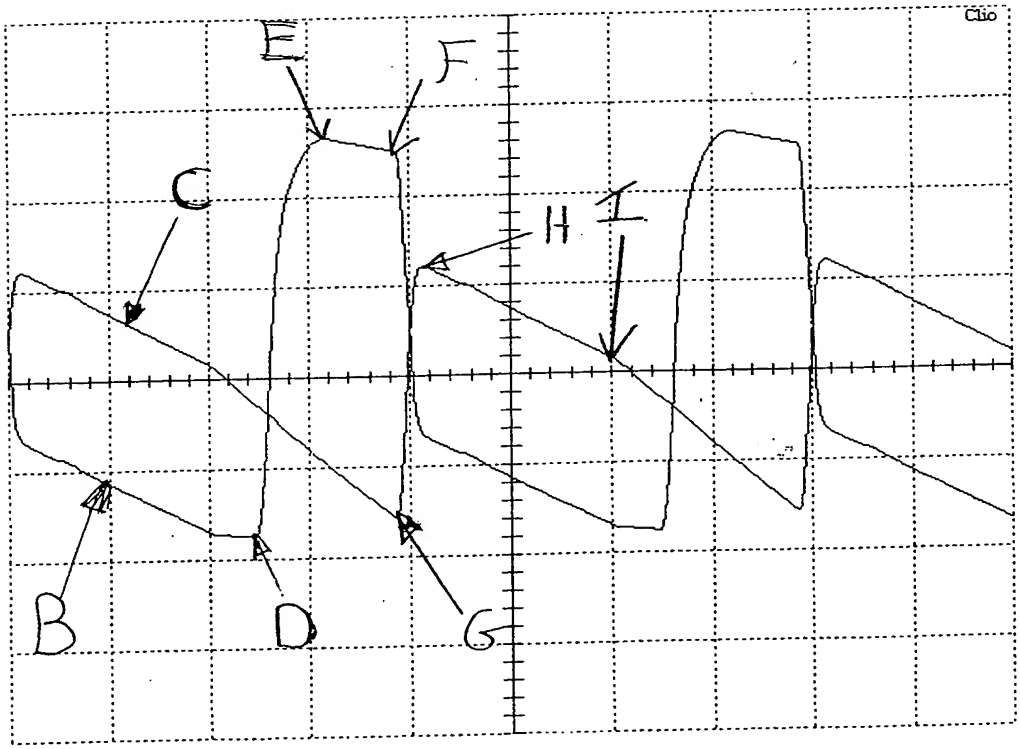
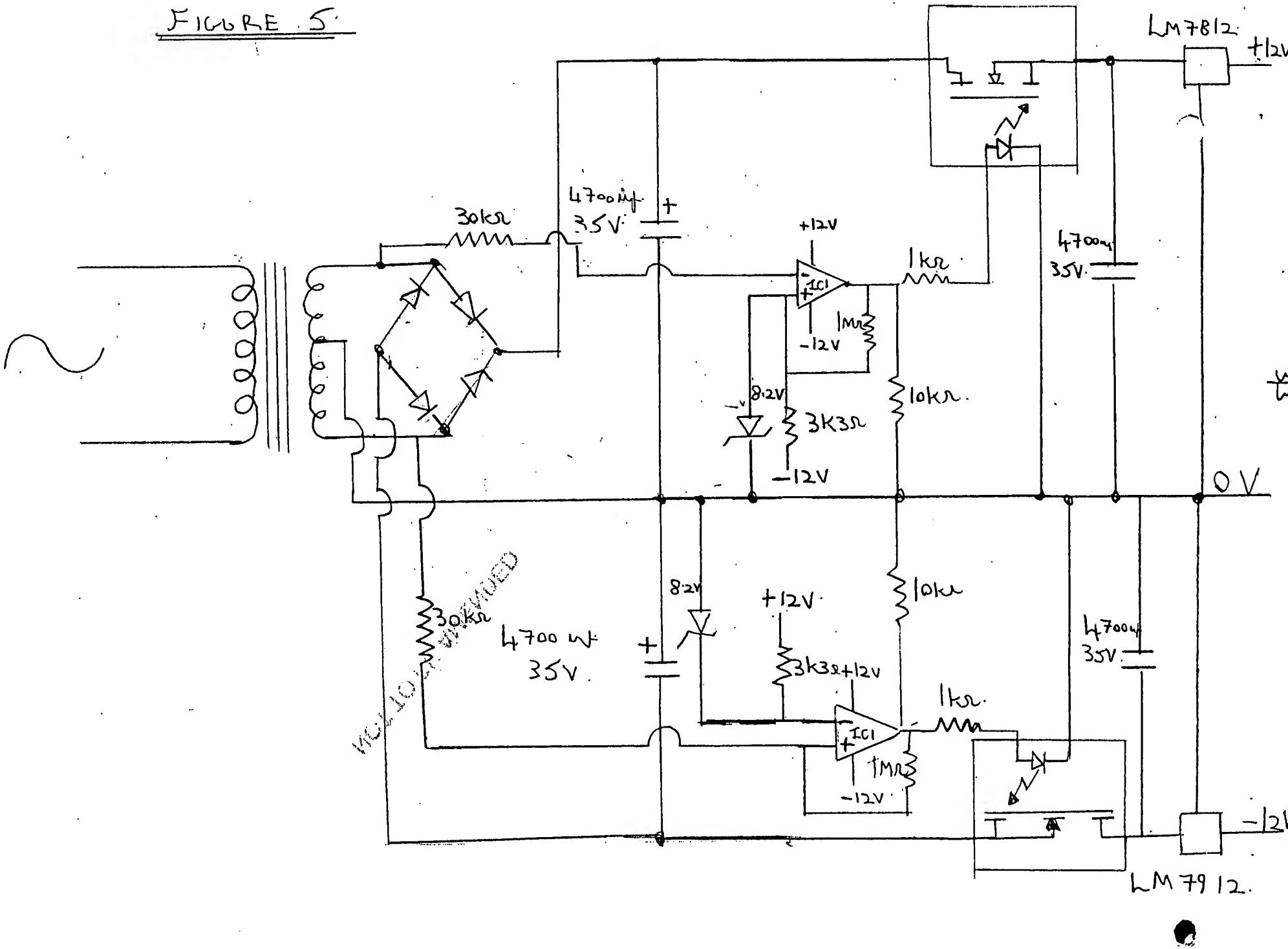


FIGURE 5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+12V
10kΩ
3k3Ω+12V
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